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Determination of Selected Material Properties of Castable Thin Film Polyimides for Applications in Solar Thermal Propulsion

By

James Patrick Paxton

Undergraduate
Senior Year

Mechanical and Aerospace Engineering Department
University of Alabama in Huntsville
Huntsville, Alabama

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This Study Will...

- Provide an Introduction to Typical Applications of Thin Film Polyimides
- Introduce 6FDA + APB Polyimides as an Important Component in Solar Thermal Propulsion
- Show Unique Methods in the Determination of Selected Material Properties of 6FDA + APB Polyimides
- Provide Modulus of Elasticity and Coefficient of Thermal Expansion Data for 6FDA + APB Polyimides

What is a Thin Film?

- Thin Sheet of a Polymer Material
- Typically .0005 - .002 Inches Thick
- Used for Stretched Membrane Mirrors and Parabolic Concentrators
- Examples of Thin Film Materials
  - Mylar™ Polyester Film
  - Kapton™ Polyimide Film
  - 6FDA + APB Polyimide Film

An Application of Thin Film Polyimides

- Solar Thermal Propulsion is Fast Becoming an Attractive Option for On-orbit Satellite Maneuvers
  - LEO to GEO Orbit
  - High Performance (Typical Isp – 600 - 1000 sec.)
  - Lightweight
- The Components of a Solar Powered Rocket Include...

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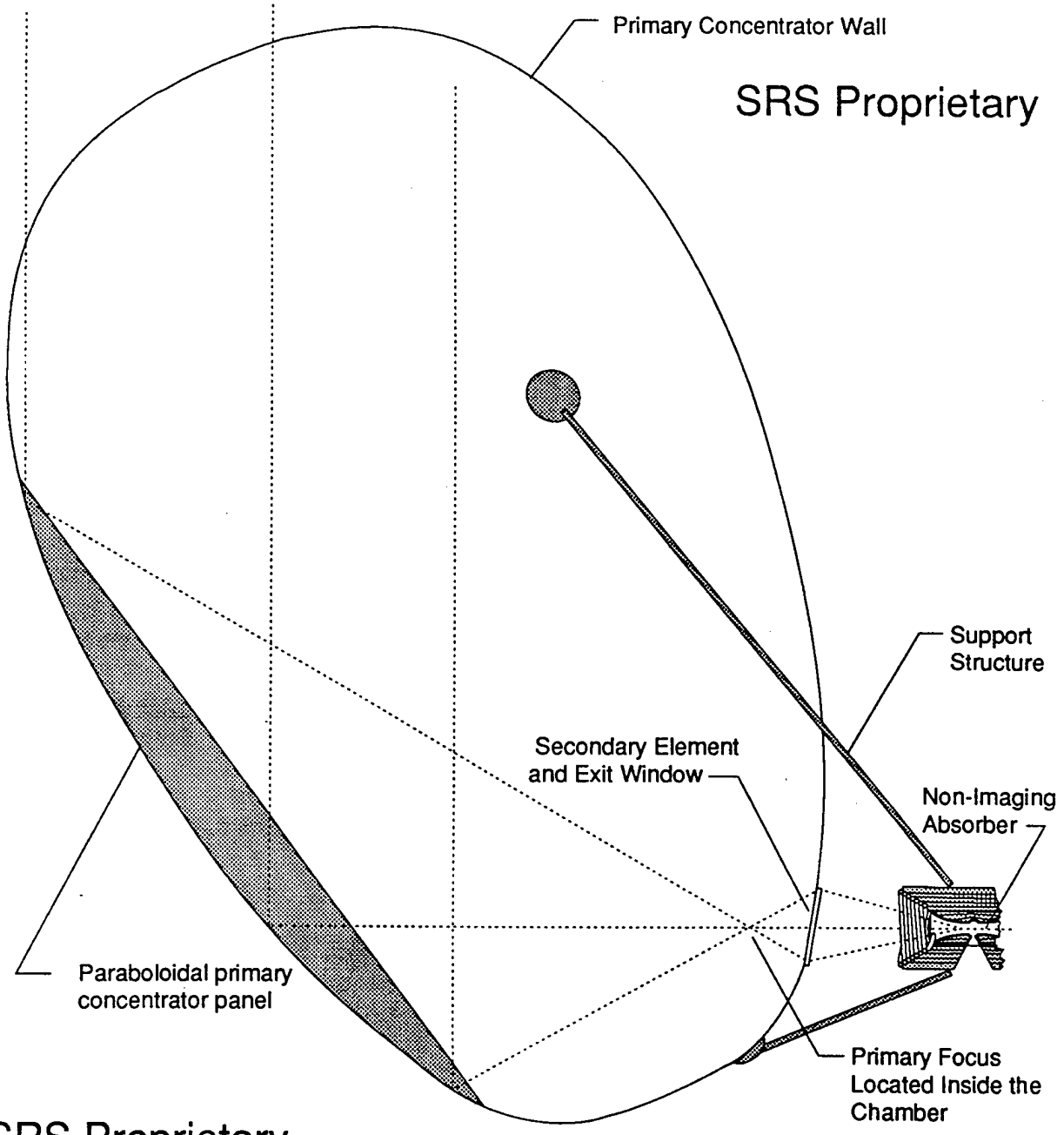
Typical Solar Thermal Rocket Configuration



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Benefits of 6FDA + APB Thin Films

- Lightweight
- Optically Transparent
- Stowable / Deployable
- Superior Material Properties
- Wide Temperature Range (-450 – 750°F)
- Castable on Curved Surfaces

Design Parameters for Articles Constructed with Thin Film Polyimides

- External Loads / Pressures
- Environmental Conditions
- Transparency
- Material Properties
  - Modulus of Elasticity
  - Coefficient of Thermal Expansion
  - Coefficient of Moisture Expansion
  - Poisson's Ratio

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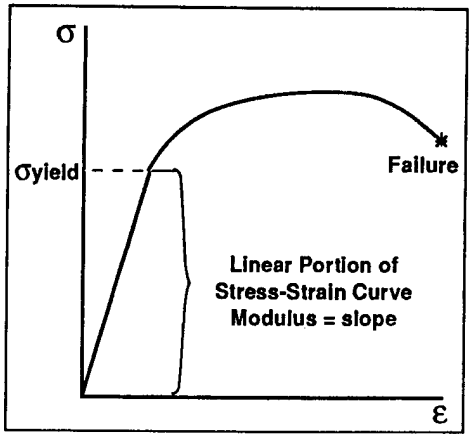
Theory

- Modulus of Elasticity (Young's Modulus) is given by Hooke's Law

$$\sigma = E\varepsilon \quad \text{(psi)}$$



- Coefficient of Thermal Expansion is given by

$$CTE = \frac{\Delta L}{L \Delta T} \quad \text{(in/(in°F))}$$

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Thin Film Test Apparatus

- Conforms to ASTM Standards
- Includes Temperature Chamber
- Provides Constant Uniform Loading
- Incorporates Unique Toggle Grip Design
- Computer Data Acquisition System

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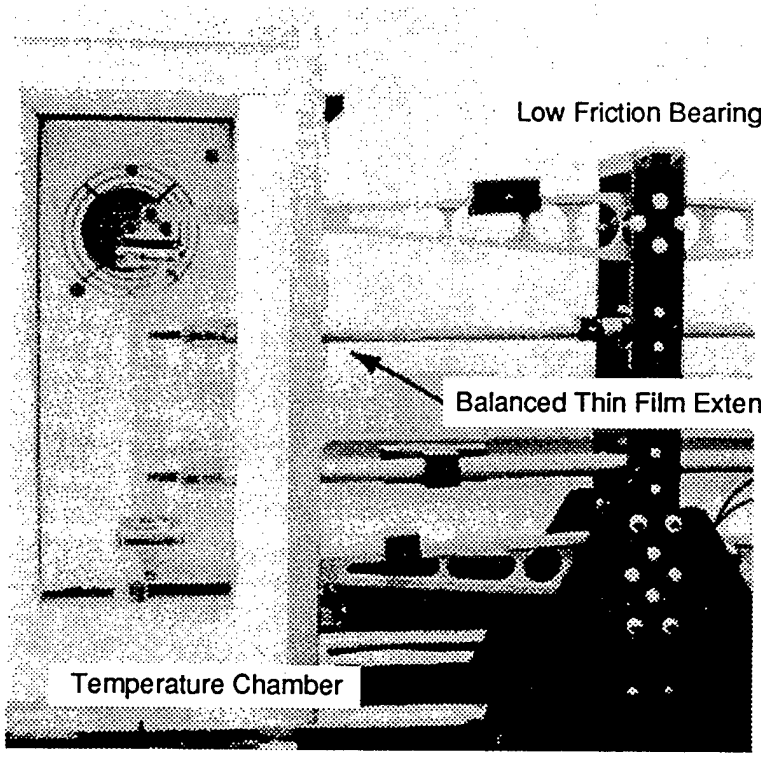
Uniaxial Test Appartus



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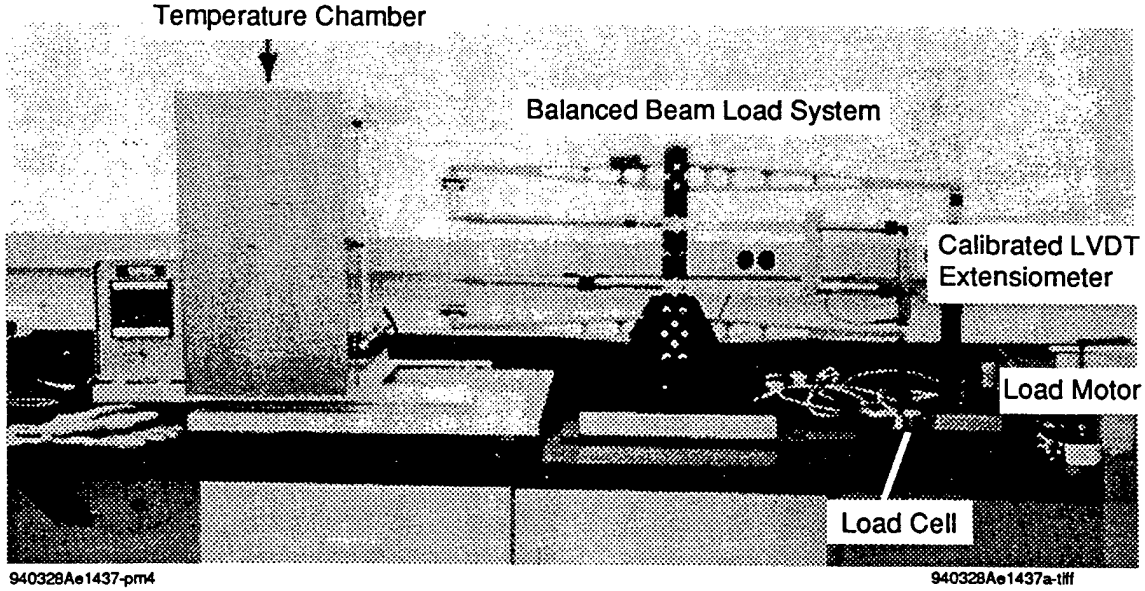
Temperature Chamber



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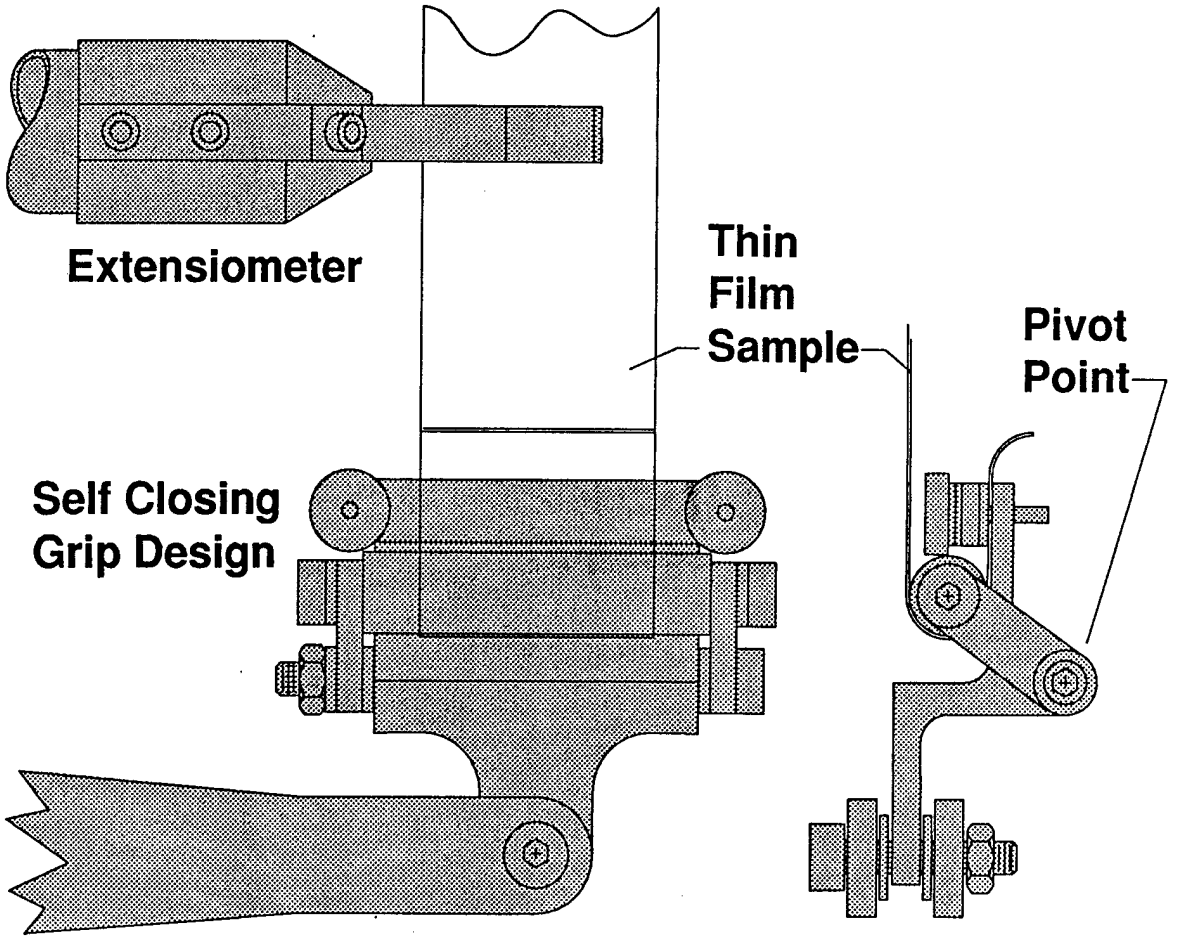
Toggle Grip Design



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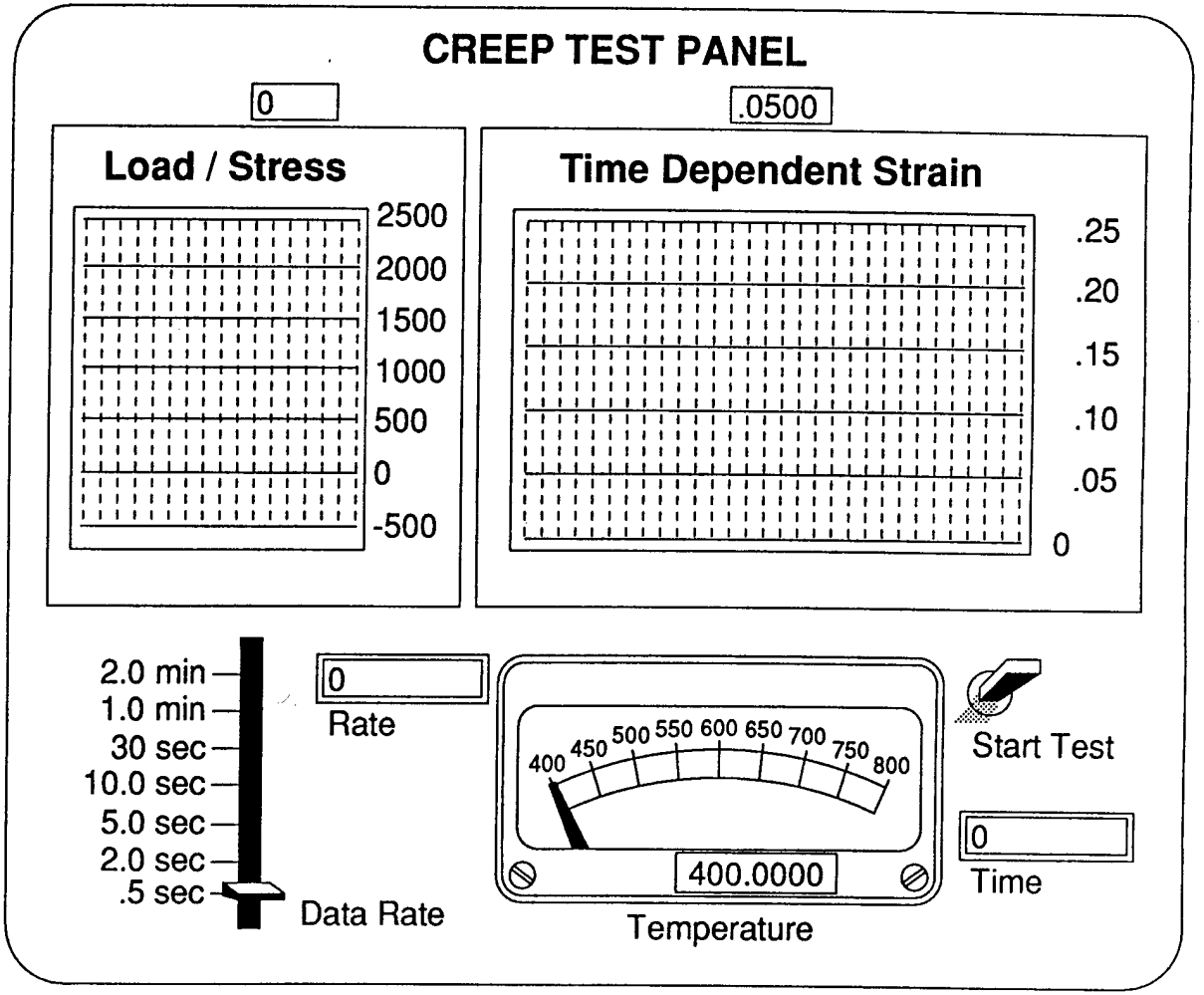
Computer Test Panel

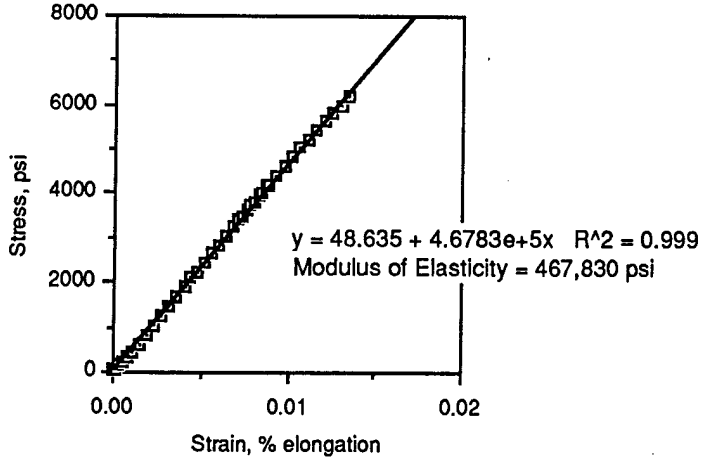


Experimental Procedure

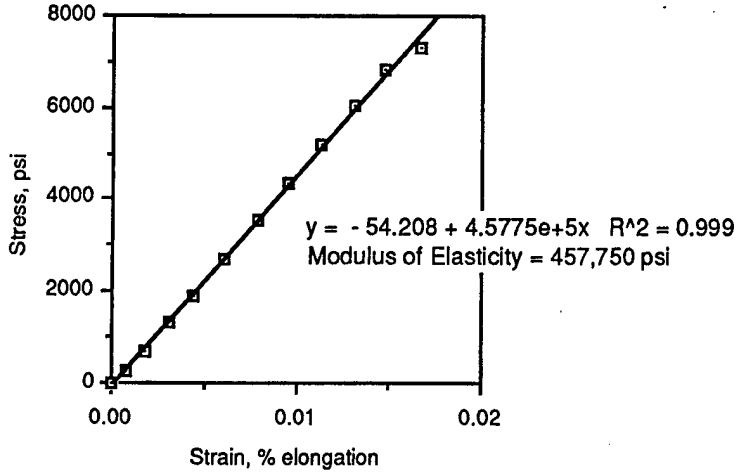
- Cast, Cut and Measure Samples
- Material Tester Calibration
- Perform Modulus Tests on Kapton Polyimide
- Perform Modulus Tests on 6FDA + APB Polyimide
- Perform CTE Tests on 6FDA + APB Polyimide
- Tabulate and Graph Results
- Compare Results to Material Source Data

Modulus of Elasticity Results

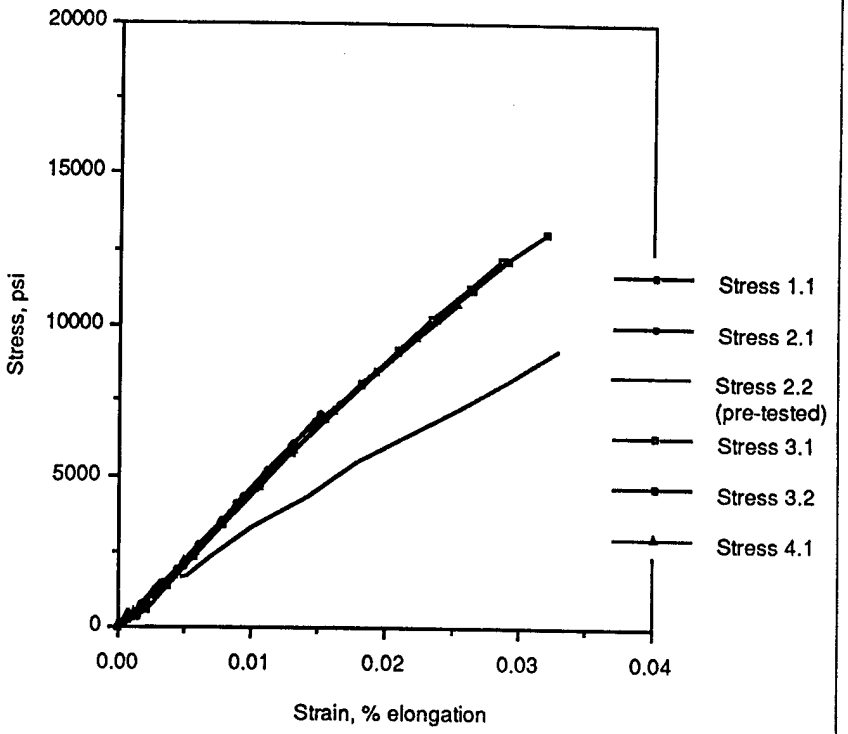
.5 mil Kapton Type H Linear Curve Fit



6FDA+APB Polyimide Linear Curve Fit



Comparison of Stress vs. Strain Curves for the 6FDA+APB Polyimide



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Modulus of Elasticity Results cont.

	Manufacturer's Data	Harris / NASA	Results of Tests	% Difference
Kapton Type H	430,000 psi 1 mil at 25 °C		467,830 psi .5 mil at 23 °C	8.8 %
6FDA + APB		426,000 psi 452,000 psi	457,500 psi 457,500 psi	7.5 % 1.3 %

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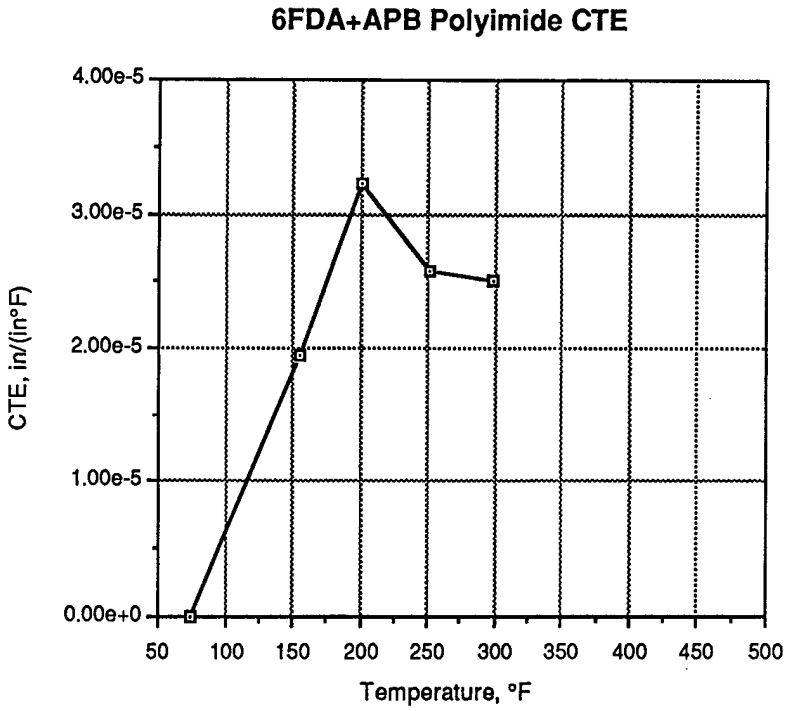
Coefficient of Thermal Expansion Results



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Coefficient of Thermal Expansion Results cont.

	Harris Data	Results of Tests	% Difference
Average CTE	27.2E-6 in/(in°F)	25.7E-6 in/(in°F)	5.7%

Conclusions and Recommendations

- All Tests Showed Good Repeatability
- Results Compared Favorably to Source Data
- Values Presented here may be used as Design Parameters for Applications of Thin Films in Solar Thermal Propulsion
- The Determination of other Material Properties is Recommended
- Furthur Investigation of the Non-linearity in the CTE Curve is Recommended

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